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Analysis and Innovation for Penetrant Testing for Airplane Parts

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Abstract

Whether the helicopter or the aerotransport, NDT methods are used in the development phase、manufacture phase 、use phase and maintenance phase .Especially penetrant testing is the efficient measure. We confirm the parts which do the penetrant testing according to the load in the development phase; Have penetrant testing after the working procedure which produce the defects in manufacture phase; Have penetrant testing for the area which use the big load in use phase. We must ensure the validity of penetrant testing in every phase. The arrangement of penetrant procedure ,surface prepare of machine parts ,protection of on-working parts, these are all the problems in the practice working. We analysis and innovate these problems, halve the experience with the other NDT technicians.

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1. Introduction

Penetration testing is an effective measure to ensure the quality of the part's surface. We met a lot of problems in the actual detection, but through joint research, we had innovated on the basis of the original technology. Adopted some new measures are more advantageous to inspect the parts. Below I will be combined with the practical work of the problems at each stage, and will share with you some of the actual test work experience and innovation.

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2. Research and development phase

In the development phase of the airplane, now the company usually adopt the joint work form in parallel, I had the opportunity to participate the joint work in parallel of several models, and have some ideas about penetration testing in the development phase:

2.1. How to determine the need for penetrant testing for parts

By comparison, I found there are differences in penetrant testing between the number and variety of parts in each model, as shown in table 1.

Table 1. Overview of the aircraft penetrant testing parts

Model	Penetrant testing basic status
Boeing	part machining
Honeywell(GKN)	machine plus 100%, sheet metal pieces of 100%
Other domestic models	machining parts is more, sheet metal is rarely
EC175-Z15	machining parts is 100%, sheet metal which are straighteninged is 100%

For some projects on the uneven, the rules of the such as Boeing only stipulated on the drawing of the project: according to the BAC5423 (W) 《penetrant testing》; Eurocopter do not stipulated on the drawing, they have special regulation for what parts need non-destructive testing, it is very specific, the workshop technician can direct do the workshop process arrangement of penetrant testing process in manufacturing instructions.

But these rules are not clear for some models, and so I put forward several Suggestions as the point of penetration technology professionals:

- At first the design personnel shall determine the importance of the parts according to the load, if the critical value of load is determined by testing for the important parts, and we should prescribe the value load if it need have penetrant testing.
- To determine which mechanical operation are the parts used during their manufacturing process, and which defects can produce after these operations, and determine whether the parts need have penetrant testing according to affect the future use.

Through the above two points, we can determined whether penetrant testing.

3. The manufacture phase

There are all kinds of problems in the process of manufacturing stage, the following are typical problems which I met in the practical work, I will talk about the critical points to share with others, hope to be helpful to the professionals.

3.1. Penetration testing process arrangement in parts process card

Usually after which process need have penetrant testing is very critical problem. Process arrangements have a rule from the perspective of penetrant testing: Perform penetrant inspection after all operations that could expose or cause surface connected discontinuities, such operations include but be not limited to: grinding、welding、straightening、machining、spin forming、heat treating etc. [1] There are two circs to need have penetrant testing in machining process:

- Process in check - the inspection after the completion of a certain process, but not all process and the process may produce discontinuity, so have penetrant inspection to ensure the quality of parts before put into next working procedure in good condition.
- Final inspection - refers to the inspection after the all process, the process may produce discontinuity or appear the discontinuity which can affect the quality of parts.

More special is penetration tests after surface treatment, in order to detect defective in the covering.

We can develop specific documentation to have process arrangement of technology for this problem, such as Eurocopter file HP0008 《inspection plan.》.

3.2. Surface preparation process arrangement before penetrant testing

We must form a complete set of surface cleaning process before Penetrant testing, because the parts before penetration test, requiring all surface is clean, dry, no dust pollution, paint, coating and other hamper penetrant infiltration discontinuity of the material.

Material cleaning process arrangement is different for Different models. Eurocopter compiled the cleaning docunment EI070-09-039 for pentrant testing, all kinds of surface condition of parts is prescribed the different cleaning steps,which is of great significance, but some content need to update, such as trichloroethylene belongs to international environmental banned drugs, environmentally friendly cleaning agents should be used instead.

3.3. Penetrant testing of the finished components

Penetrant testing generally applicable to the detection of individual parts, for a component, due to combine surface, material is easy to filter into the inside, and that can't be cleaning, for long residual, in a specific environment, such as wet can produce harmful effects, such as produce corrosion by unused penetrant. So we does not advocate penetrant testing for the component, General requirements if necessary we can break down the composition as far as possible, unable to break down the components, we require invite professional non-destructive people to check the detection area, the key is the detection area can be effective protection. The following interpretation is a typical component which I met in the work.

The again machining surface on the fixed ring components of my factory production need do penetrant testing according to the drawing requirements, about the situation for this component to:

- Detection area is the area within the dotted line as shown in figure 1, there are 18 only ϕ 5 mm diameter threaded holes.
- The need to protect is as shown in the combination of plane and 4 incisions, and 18 threaded holes in accordance with the design requirements.
- A local test for the critical part, cannot use the spray can of color to detect, although spray cans be convenient operation, but the sensitivity can't meet the requirements. [2]
- Locally applied, use level 3 or higher sensitivity of the fluorescent penetrant which remove by the solvent.

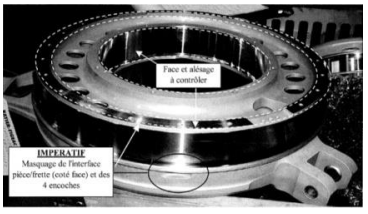

Fig.1. the fixed ring component

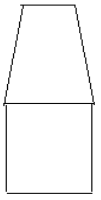

Fig .2. the special plastic pin

For this component, we first consider the protection of the detection area before penetrant, I have seen the original English test process card this component, from a professional point of view I don't think of his design process card is rigorous, is likely to cause the testers to leave out the defects, so we carried on the innovation: after much trial and error, to achieve a satisfactory detection requirements, we adopt the following protection methods:

- Dip the viscous oil with toothpicks to seal interface and incision. The oil has no effect on the subsequent use of components
- The production of special plastic pin block 18 threaded hole, as shown in figure 2.
  Make the square bottom of the pin dip in with oil, then screw into the threaded hole, then use cotton cloth dipped

in the solvent to wipe clean the edge of the joint surface between the pin and screw thread, so penetrant cannot penetrate into surface, also does not affect to the edge detection, the interference of penetrant which return shows almost no, don't worry after the post-cleaning problems. The method principle of practicality is very strong.

3.4. Etching of the parts before penetrant testing

Frankly speaking is corroding a very thin layer on parts surface by solution ,it is not all the parts need to be etched before penetrant examined in practice ,it is controversially what parts need to etch?

Etched in the practical work, aluminum alloy parts is very common, because aluminium alloy is a soft metal, easier to plug in the processing course. For parts finished by nc machining are very good, needn't be polished, so needn't be etched before penetrant testing. The burrs must be grinded if these are burrs on the ordinary processing surface, generally use the 300-320 emery cloth to make rough grinding, then use the 500 sandpaper to make fine grinding . The repeated grinding area must be carried out etching to ensure the effectiveness of the penetrant testing. [3]

3.5.Post-cleaning after penetrant testing

After penetrant testing, generally it need cleaning process for parts, to remove residual penetrant and developer from the parts surface. Now for I contact model, there are three conditions for the cleaning:

- Only use compressed air to remove surface residue, this method can only remove about, can't completely.
- Wash by the water, and then thoroughly dry parts.
- Dry after water washing, clean with trichloroethylene again.

These three methods are feasible, just from a different perspective, because the parts after penetrant testing need to wash it again before the next procedure, to ensure that the surface is clean. The time interval between the next procedure and penetrant testing need be considered, because in the humid environment, it is prone to corrosion when residual penetration materials contact with the water. So proposal for key parts, we should increase the time interval between the two working procedure in the workshop process card for important parts to ensure the safety of the parts.

4. Use phase

4.1. Surface preparation prior to penetration testing for parts in service

Aircraft in use process, the requirement for the part of the problem area do penetrant detection, the surface of the used parts will be a serious pollution, oxide and other interfere, if the parts can be disassembly, we can adopt the method of acid pickling; if you can't be disassembly, we can use sand paper burnish the part or inspected area, then etched away a thin layer, and then we can proceed penetrant testing .

There are a lot of practical factors for locale inspection, Temperature and oil infiltration jams have great influence on the penetration test results, so heating program can maintain high testing sensitivity at ambient lower temperature. For the part's surface which long-term contain oils can be used steam or solvent cleaning agent cleaning, if not using the pre-cleaning method of steam, it can effectively remove the oil in the defects by the hot air or electricity heating lamp on local heating surface, to enhance the penetration of penetrant.

4.2. The protection of local detection for parts

The parts which can't be disassemble from the airplane, need protect adjacent areas and combination surface before penetrant testing, once the penetrant material enters the combination surface, it will be very difficult to clean. Usually we adopt polyethylene film and protection cover to protect, and apply penetrant using the brush. But in fact the protection effect of adhesive tape and grease is the better than the adhesive tape method, the latter of anti-penetrant effect is very ideal.

4.3. Penetrant testing of composite material parts

Penetrant examined in domestic, does little to composite material, usually think penetrant testing is only applied in the metal material, in fact, penetrant testing method can also be used for surface defect inspection of composite materials. Now there are special penetrating materials for composite materials in the international. I used solvent penetrant ARDROX 9705 to carry out penetrant test on the blade. The ability to defect detection is no problem, my main concern is the removing of penetrant material can thoroughly, the effect for follow-up for composite materials, this is the direction I need to continue to explore.

5. Maintenance phase

Airplane after a certain period flight need conduct a comprehensive maintenance, the maintenance phase penetrate testing is the most commonly used methods, professional first determine the site testing, usually for long-term stress focus on areas or parts of big larger load .

In a lot of the field of maintenance, cleaning before penetrant testing is non-standard, just using the solvent to wipe, especially for frequently used parts which defects are easily blocked, maintenance surface cleaning can be reference to the following:

- Clean the testing surface, wipe with clean cotton cloth which dip solvent remover.
- Protection non-testing surface with polyethylene film and electroplating tape, to ensure that the joint surface does not enter the etchant.
- Brushed rework area about 2 min with 10% industrial sodium hydroxide (NaOH) solution.
- We should keep etchant moist surface in the process of etching treatment. Note: the etchant of aluminum has strong corrosive, should be a mandatory strictly abide by the protection.
- Wipe corrosion surface to remove sodium hydroxide solution by water wet cloth.
- Wipe industry solution surface with 10% nitric acid (HNO3) to neutralize sodium hydroxide solution.
- Wipe the rework area to remove nitrate by water wet cotton cloth. Then Wipe with a clean, dry cotton cloth.
- Remove polyethylene film, wipe with solvent remover wet cotton cloth, remove any protection with those left on the surface residue.
- Check the rework area again. If the defect indications appear again, it is submitted to the engineering department again.
- The remains of penetrant materials shall be removed after penetrant testing (e.g., developer).

6. Concludes

Above is my some opinions of penetrant testing in many years of working, these are the practical problems in the daily work. I analyzed these problems, and summarized the innovation point of our works, hope to help the nondestructive testing personnel in the same industry.

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